

Claims:

1. A method of detecting manatee vocalizations, comprising the steps of:

detecting sounds in an underwater region;
generating a digital representation of said sounds;
filtering out sounds at unwanted frequencies from said digital representation, wherein filtered data in a frequency range of interest is maintained;

forming a plurality of overlapping time-windowed portions of said filtered data;

estimating, for each of said plurality of overlapping time-windowed portions, a power spectrum for frequency bins in said frequency range of interest;

normalizing, for each of said plurality of overlapping time-windowed portions, each said power spectrum for each of said frequency bins thereof using an average of power spectrums calculated over a plurality of said frequency bins, wherein a normalized spectrum value is defined for each of said frequency bins and wherein each said normalized spectrum value associated with broadband noise has a value that is less than each said normalized spectrum value associated with narrowband tones;

providing a lowest resonant frequency of interest associated with manatee vocalizations, wherein said lowest

24 resonant frequency has harmonics associated therewith;
25 filtering out, for each of said plurality of
26 overlapping time-windowed portions, normalized spectrum
27 values indicative of narrowband tones that occur (i) in
28 windows of frequency bins encompassing frequencies lower and
29 higher than each of said lowest resonant frequency and said
30 harmonics thereof and (ii) with a specified degree of
31 variance with respect to frequency separation therebetween,
32 wherein a resulting number of said normalized spectrum values
33 indicative of narrowband tones are maintained;
34 assigning, for each of said plurality of overlapping
35 time-windowed portions, each said normalized spectrum value
36 from said resulting number thereof to a frequency based
37 harmonic set, each of which is defined by a base frequency
38 and resonances thereof; and
39 applying, for each of said plurality of overlapping
40 time-windowed portions, a scoring routine that uses each said
41 normalized spectrum value in each said harmonic set wherein a
42 manatee vocalization is indicated when a threshold score is
43 achieved across at least a portion of said plurality of
44 overlapping time-windowed portions.

1 2. A method according to claim 1 wherein said step of
2 estimating comprises the step of performing a periodogram on

3 each of said plurality of overlapping time-windowed portions.

1 3. A method according to claim 1 wherein said average of
2 power spectrums used in said step of normalizing is based on
3 frequency bins that are less than said frequency bin of said
4 power spectrum being normalized if a first quantity is
5 greater than a second quantity, said first quantity defined
6 by said power spectrum being normalized minus an average of
7 power spectrums based on frequency bins that are less than
8 said frequency bin of said power spectrum being normalized,
9 and said second quantity defined by said power spectrum being
10 normalized minus an average of power spectrums based on
11 frequency bins that are greater than said frequency bin of
12 said power spectrum being normalized.

1 4. A method according to claim 3 wherein said average of
2 power spectrums used in said step of normalizing is based on
3 frequency bins that are greater than said frequency bin of
4 said power spectrum being normalized if said first quantity
5 is not greater than said second quantity.

1 5. A method according to claim 1 wherein said scoring
2 routine comprises the steps of:

3 evaluating each said harmonic set in accordance with a
4 set of rules;

5 assigning a score of zero to each said harmonic set not
6 satisfying said set of rules; and

7 forming a score for each said harmonic set satisfying
8 said set of rules, said score being determined using said
9 value for each said normalized spectrum in each said harmonic
10 set satisfying said set of rules.

1 6. A method according to claim 1 further comprising the step
2 of displaying a visible indicator each time said threshold
3 score is achieved across said portion of said plurality of
4 overlapping time-windowed portions.

1 7. A method according to claim 1 further comprising the step
2 of producing an audible indicator each time said threshold
3 score is achieved across said portion of said plurality of
4 overlapping time-windowed portions.

1 8. A method according to claim 1 further comprising the step
2 of producing a tactile indicator each time said threshold
3 score is achieved across said portion of said plurality of

4 overlapping time-windowed portions.

1 9. A system for detecting manatee vocalizations comprises:

2 means for detecting sounds in an underwater region;

3 means for generating a digital representation of said
4 sounds;

5 means for filtering out sounds at unwanted frequencies
6 from said digital representation, wherein filtered data in a
7 frequency range of interest is maintained;

8 means for forming a plurality of overlapping time
9 windowed portions of said filtered data;

10 means for estimating, for each of said plurality of
11 overlapping time-windowed portions, a power spectrum for
12 frequency bins in said frequency range of interest;

13 means for normalizing, for each of said plurality of
14 overlapping time-windowed portions, each said power spectrum
15 for each of said frequency bins thereof using an average of
16 power spectrums calculated over a plurality of said frequency
17 bins, wherein a normalized spectrum value is defined for each
18 of said frequency bins and wherein each said normalized
19 spectrum value associated with broadband noise has a value
20 that is less than each said normalized spectrum value
21 associated with narrowband tones;

22 means for filtering out, for each of said plurality of

23 overlapping time-windowed portions, normalized spectrum
24 values indicative of narrowband tones that occur (i) in
25 windows of frequency bins encompassing frequencies lower and
26 higher than each of a lowest resonant frequency of interest
27 associated with manatee vocalizations and harmonics thereof
28 and (ii) with a specified degree of variance with respect to
29 frequency separation therebetween, wherein a resulting number
30 of said normalized spectrum values indicative of narrowband
31 tones are maintained;

32 means for assigning, for each of said plurality of
33 overlapping time-windowed portions, each said normalized
34 spectrum value from said resulting number thereof to a
35 frequency-based harmonic set defined by a base frequency and
36 resonances thereof; and

37 means for applying, for each of said plurality of
38 overlapping time-windowed portions, a scoring routine that
39 uses each said normalized spectrum value in each said
40 harmonic set wherein a manatee vocalization is indicated when
41 a threshold score is achieved across at least a portion of
42 said plurality of overlapping time-windowed portions.

1 10. A system as in claim 9 wherein said means for detecting
2 sounds in an underwater region comprises at least one
3 hydrophone.

1 11. A system as in claim 9 wherein said means for generating
2 a digital representation of said sounds comprises an analog-
3 to-digital converter.

1 12. A system as in claim 9 wherein said means for filtering
2 out sounds at unwanted frequencies from said digital
3 representation comprises a bandpass filter.

1 13. A system as in claim 9 further comprising a display
2 coupled to said means for applying for displaying a visible
3 indicator each time said threshold score is achieved across
4 said portion of said plurality of overlapping timewindowed
5 portions.

1 14. A system as in claim 9 further comprising a sound
2 reproduction device coupled to said means for applying for
3 producing an audible indicator each time said threshold score
4 is achieved across said portion of said plurality of
5 overlapping time-windowed portions.

1 15. A system as in claim 9 further comprising a device
2 coupled to said means for applying for producing a tactile
3 indication each time said threshold score is achieved across
4 said portion of said plurality of overlapping timewindowed

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5 portions.